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ABSTRACT. A description is given of the construction, optical and kinematic parts of the astrophysical observatory "Orion," installed in the orbital station "Salyut." The "Orion" consists of a mirror telescope of the Mersenne system with a clear diameter of the large mirror of 280 mm and slitless spectrograph of the Wadsworth system with a diffraction lattice. The camera with a film gate is firmly fastened, the spectrograph is adjusted and focused by shifting the diffraction lattice. The part is given elastic swings with the aim of enlarging the spectrogram up to 0.4 mm. A stellar photoguide designed to catch and guide stars up to 4^m is fastened to the body of the telescope, parallel to its optical axis. The part of the modulator of the stellar guide is hermetically sealed. The telescope is mounted on a biaxial installation of the Cardan suspension type. In flight the telescope is sealed by means of two separation charges to the body of the spacecraft. Unsealing is effected after the station is put into orbit. The "Orion" is equipped with a sight system of guidance and on-board control desk with programming device.

The "Salyut" space station, put into orbit around the earth in May 1971, /12*
carried the "Orion" astrophysical observatory. It was designed primarily for obtaining individual spectrograms of hot stars in the wavelength region 2000-3800 Å with a spectral resolution of about 5 Å (at 2600 Å). The operation of the "Orion" in orbit was controlled by a cosmonaut who at all times was within the space station. The principle of joint work of the cosmonaut and "Orion" automatic systems was described in [1].

In essence the "Orion" was the first significant experiment in placing an astrophysical observatory in outer space on a space station, directly on its body. In addition, the "Orion" retained its operability for a relatively long time, for almost 2 1/2 months, reckoning from the time it was put into orbit to the moment when the "Salyut" crew departed from the station. It goes without saying that this could not be achieved without ensuring the necessary level of engineering development of the entire complex, beginning with the overall design of the "Orion," and ending with its individual units and components.

* Numbers in the margin indicate pagination in the foreign text.

Assuming that this experiment can be useful in developing similar experiments in the future, we found it desirable to devote a separate article to a brief description of the design and layout of the "Orion" apparatus.

A mirror telescope of the Mersenne system with a clear diameter of the large mirror of 280 mm, a small mirror with a diameter of 50 mm and a focal length of 1,400 mm, are the basic "Orion" components. The total diameter of the large mirror is 300 mm and thickness at the center is 18 mm. An aperture with a diameter of 80 mm is left at the center of this mirror for convenience in optical adjustment of the telescope.

A slitless spectrograph of the Wadsworth system with a concave diffraction grating, in whose focus, at a distance of 250 mm from it, a spectrogram of the ¹³ object is constructed in the range 2000-3800 Å ("Orion" optical system, see [2]), is mounted opposite the parallel light beam reflected from the second mirror.

Both "Orion" mirrors are fabricated from sital and their mountings are of invar; the coefficients of linear expansion of the sital and invar which we used are almost identical within the range of the expected temperature of the elements. The mirrors were set freely in their mountings with a gap between the mounting and mirror measuring 0.003-0.005 mm. The mirrors were coated with aluminum without any protective layers.

In order to keep the light beam reflected from the second mirror parallel during temperature fluctuations the spider of the Mersenne mirror was secured in the main mirror mounting by three invar spacing rods. The telescope tube was designed in the form of a tube of titanium alloy with a rigid band to which was attached a spectrograph and the other instruments by means of which the telescope is set in its mounting.

The spectrograph consists of three principal parts: the diffraction grating unit, cameras and mechanism for broadening the spectrogram. The camera with the film channel (that is, with the focal plane) is attached to the body of the spectrograph securely, and adjustment and focusing of the spectrograph itself are accomplished only by movements and rotations of the diffraction grating itself. Accordingly, we designed a diffraction grating unit which ensures its smooth movement along the optical axis of the spectrograph and smooth rotations about two mutually perpendicular axes. The determined final position of the diffraction grating was fixed and then tightly secured.

The camera begins with a curvilinear film channel, constituting part of a circle with a radius of 103 mm. The open width of the channel is 12 mm, which is adequate when working with a film 16 mm wide. There are two magazines in the camera; feeding and receiving, as well as a drive for rewinding the film in the receiving magazine. The latter is attached to the spectrograph body by means of a firing pin. After implementing the "Orion" work program, by a separate command from the spacecraft's control panel, this magazine is separated simultaneously both from the body of the camera and from the rewinding drive, after which it is conveyed within the spacecraft through a special lock built into its body. The separation (release) of the receiving magazine is accompanied simultaneously by the performance of two other operations: automatic cutoff of the film remaining unused in the feeding magazine, and covering of the magazine entrance slit by a small lid.

In front of the film channel, in a special slot, there is a quartz plane-parallel plate 2 mm thick serving as a light filter for eliminating the second ⁰ order of the spectrum (that is, in the region shorter than 1900 Å) from our working range. Here there is also a camera shutter, designed in the form of a cylindrical tube with a broad slit rotating about its longitudinal axis. Rotation is accomplished using an electromagnet in response to a signal fed from a programming device at the time of film rewinding. /14

The entire channel for film movement from the feeding mechanism through the film channel to the receiving magazine is designed in such a way as to preclude the possibility of contact with the metal of the central band, 10 mm wide, and the sides of the emulsion-covered film.

With respect to broadening of the spectrograms (measuring 0.4 mm), this is accomplished using an ordinary cam mechanism imparting elastic oscillations to the diffraction grating unit in the plane perpendicular to the direction of dispersion. One should mention the very good uniformity which was achieved in the broadened spectrogram in this way. Checking of the uniformity of spectrogram broadening was accomplished using an optical-mechanical stand specially created for this purpose. The spectrograph was fabricated for the most part from titanium alloys.

A two-coordinate star photoguide was mounted on the telescope body parallel to its optical axis. It is designed for intercepting the star (to $4^m-4.5^m$)

whose spectrogram must be obtained, and automatic tracking (guidance) after it with an accuracy to 10". The photoguide operates on the principle of a mirror knife-modulator rotated by an electric motor in combination with a reference voltage generator (for details, see [3]). The photoguide-lens (coated lens) optical system has a field of view 3° , an entrance pupil diameter 70 mm, focal length 450 mm, and response threshold 5". The photoguide had a folding diaphragm reducing the field of view to $40'$; this made it possible to intercept and track objects in whose immediate neighborhood bright stars are situated.

Particular attention was devoted to ensuring perfect sealing of the star photoguide modulator unit with the driving electric motor and reference voltage generator; these units were cast in a hermetically effective material. The total sealing of this unit required use of an adaptation device for pumping dry air and checking the possibility of sweating of the optical component in the receiving part of the photoguide at low temperatures.

On the telescope body there is also a small platform for mounting, as desired, other special-purpose instruments. For example, in those cases when there are some bright nebulae within the limits of the viewable region of the sky (in the direction of the shaded part of the orbit) during the period when the orbital station is put into orbit, by mounting a portable nebular spectrograph on the mentioned platform an attempt can be made to obtain their spectrograms. In such cases the feeding and receiving magazines are fabricated in one piece with the film channel in the form of a separate small unit. This unit is attached to the body of the spectrograph by means of another firing pin; by command from the on-board control panel it can be separated and transported within the spacecraft the same as in the case of the star spectrograph. /15

The telescope with all the instruments attached to it is attached to a Cardan type mounting. Since the telescope is designed for obtaining the spectrograms of individual stars, in this case it is sufficient to have a biaxial mounting with two drives. The latter operate in response to mismatch signals fed from the star photoguide. The drives are constructed with partially "canned" reducers using special electric motors suitable for operation in space. The last two pairs of transmission gears in the drives are supplied with clearance-selecting devices. The bearings and transmission gears are sealed tightly by fluoroplast packings. Standard ball bearings and a consistent lubricant were used.

In order to safeguard the instruments and drives from the effect of vibration loads, impacts and accelerations in the active segment of rocket motion, the entire telescope unit and its mounting were locked in a transport position onto the body of the ship by means of two firing pins. The firing pins were released after the station had been put into orbit by pressing a button on the "Orion" control panel.

The entire "Orion" telescope unit with its mounting were attached to the outer surface of the space station in a niche specially provided for this purpose. On the outer side this niche was covered by a shielding-vacuum heat insulation, other than for the entrance apertures of the optical instruments. This ensures the necessary temperature regime for the "Orion" instruments due to heat diffusion from the station body. There was not special heating of any part of the "Orion." The general structure and layout of the telescopic unit of the "Orion" system is shown in Figure 1 in two projections.

The sighting system was an important component of the "Orion." It was designed for remote guidance of the telescope unit mounted on the outside onto the object to be investigated by means of a synchronized tracking system with an accuracy ensuring interception of the object (star) by the star photoguide. Only after this is the precise guidance and automatic tracking system triggered, but without participation of the operator. The actual search for the object is performed visually by the cosmonaut, but pointing of the sighting tube on it is done manually, using the key switches.

The sighting system is a collimator sight attached to a small biaxial mounting. The latter is electrically connected to the telescope mounting by two electromechanical drives and the rough tracking system with potentiometric angle sensors (for details see [3]). The sight has two angular pointing speeds, slow ($15' \text{ sec}^{-1}$) and fast ($1.5^\circ \text{ sec}^{-1}$). The sight field of view is square with 35° sides, the field of view of the magnification tube is 9° , magnification is 6x and angular resolution is $1'$.

The entire sighting system is mounted within the orbital station, in front of one of its windows, situated not far from the niche of the main "Orion" apparatus.

The sight and the telescope unit with its mounting after being mounted aboard the station are mutually adjusted with an accuracy of about $10'$ so that

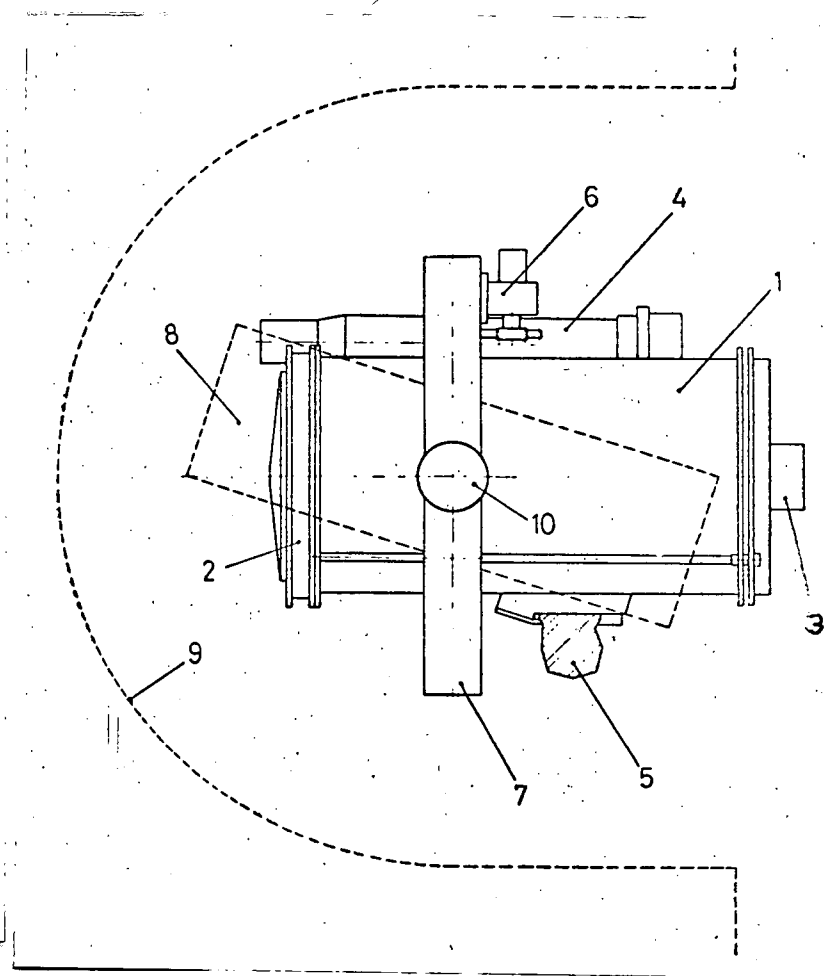
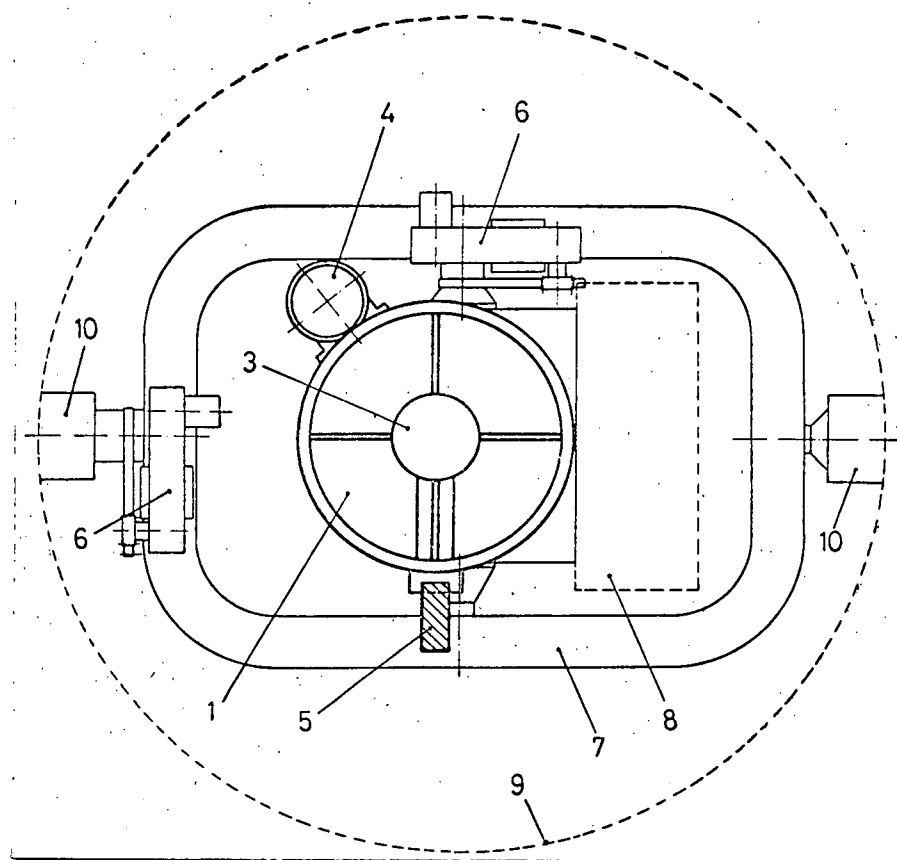


Figure 1. Layout and schematic appearance of "Orion" observatory.
 1 - telescope with slitless star spectrograph; 2 - holder of large mirror; 3 - holder of small mirror; 4 - star photoguide; 5 - star spectrograph magazine; 6 - electric drive of tracking system; 7 - biaxial mounting; 8 - site of attachment of spare instrument; 9 - niche on body of ship; 10 - sites of "Orion" attachment in niche.

their optical axes will be parallel. The ending of the mismatch between the principal axes of both systems during standard work is accomplished using signals fed from the potentiometers set on the mounting axes of both units.

The "Orion" system also includes an on-board control panel. It is designed in the form of a rectangular box of relatively small size and is mounted near the finder telescope. Using this control panel the cosmonaut controls all the "Orion" systems, beginning with release by use of firing pins and ending with the magazines being conveyed through the lock. Control itself is accomplished by feeding commands in both automatic and manual regimes. The control panel is also used in monitoring implementation of commands and monitoring the state of visual indication systems. /18

The control panel box also contains the programming device, ensuring an automatic survey cycle from one to five spectrograms for one star, depending on its brightness, with exposures from 10 to 810 sec. In addition, work is possible in a manual regime in which it is possible to photograph the spectrogram of a star with any exposure (not more than 30 minutes, that is, the duration of presence of the station in the shaded part of the orbit) using a stopwatch.

Apparatus of the "Orion" system and its individual components underwent the usual cycle of ground tests, including tolerance to vibration and the cold and vacuum tests.

A. Kashin, N. Arakelyan, E. Kazaryan, R. Isadzhanyan, M. Arutyunyan, and A. Sarksyian participated in developing the design and kinematic systems of the telescope, spectrograph, and auxiliary parts of the "Orion." Adjustment and focusing of the optical systems of the "Orion" and ground tests of the instrumentation were carried out with the direct participation of G. Loretsyan, Dzh. Oganessian, R. L. Oganessian, and R. Yepremyan. The "Orion" apparatus was fabricated in the "Astro" Special Design Bureau under the supervision of Ye. Sar'yan and R. Babayan.

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